United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

ENERGY EFFICIENT BUILDING ENVELOPE

CODE 672

(no)

DEFINITION

A boundary between a conditioned space and an unconditioned space that meets or exceeds thresholds for energy efficiency.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Improve energy efficiency of an existing agricultural building envelope.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to any partially or fully conditioned agricultural building or space. A partially conditioned space is a building or space using both mechanical ventilation and natural ventilation. Ventilation systems can be used individually or at the same time. Examples are curtain-sided poultry broiler or swine finishing houses, and dairy milking parlors. A fully conditioned space is a building or space using fans, heaters, or other mechanical devices for year-round conditioning of space. Mechanically ventilated systems can be negative, positive, or neutral pressure. Examples are fully ventilated poultry layer houses or swine farrowing rooms, and milk storage rooms.

A building envelope or boundary may include walls, doors, windows, roof or ceiling, and foundation or floor of a building.

This practice does not apply to residential spaces or buildings.

CRITERIA

General Criteria Applicable to All Purposes

Implement building envelope improvements based on the building tightness, insulation, and ventilation needs of the facility for the intended purposes of each area or space.

Comply with all applicable building codes and National Fire Protection Association (NFPA) 150, “Fire and Life Safety in Animal Housing Facilities Code” as well as any local, State or Federal regulations.

Prescriptive upgrades

Building envelope upgrades included on the State-approved prescriptive list improve energy efficiency, as such, design and implementation do not require additional specific computations for efficiency.

For building envelope improvements not included on the State-approved prescriptive list, utilize the following general critieria and the appropriate additional criteria sections below.

Air leakage through building envelope

Evaluate air leakage paths using one or more of the following methods:

- Building depressurization or pressurization with all windows and doors closed using approximately 1 cubic feet per minute (cfm) per square feet (sf) ventilation rate of floor space with smoke tracer or theatrical fog.
- Visual inspection with smoke tracer or theatrical fog.
- Other appropriate methods accepted by the NRCS State conservation engineer (SCE).

Design an air barrier system based on the intended use of the space to seal air leakage paths identified during the evaluation.

Create air barriers in building envelope or between spaces that have either significantly different temperature or humidity requirements.

The air barrier must not displace under load or displace adjacent materials. Use flexible connections between roof air barrier, wall air barrier, window frames, door frames, foundations, floors over crawl spaces, ceilings under attics and across building joints to withstand building movements due to thermal changes, seismic activity, moisture content changes, and creep. The joint must support the same air pressures as the air barrier material without displacement.

Use air barrier material that is durable or accessible for maintenance.

Verify leakage paths have been adequately sealed using one of the evaluation methods listed above.

Install air barriers in accordance with the manufacturer's recommendations.

Additional Criteria for Insulation

Select insulation and covering materials that are durable, moisture resistant, nontoxic to humans or livestock and perform the intended function under the conditions the material is expected to encounter during normal use, including temperature extremes, moisture, ultraviolet (UV) light exposure, cleaning products, disinfectants, mildew, puncture by equipment, corrosion, and flammability. Where applicable, follow any U.S. Food and Drug Administration (FDA) regulations.

Select and install insulation and covering material to discourage entrance and chewing by rodents, pecking by birds, infestation by insects, or damage by livestock.

Secure insulation where it is susceptible to displacement by animals, equipment, wind, or air movement. Protect exposed flammable insulation with thermal barriers as defined in fire safety requirements below.

In Climate Zones 4 through 8, install insulation to at least 18 inches below ground level along the building exterior perimeter with minimum R-values shown in table 1, column "Walls, below grade" for the appropriate building type, except in instances such as an existing concrete slab is adjacent to the building.

Install insulation according to manufacturer's recommendations. Ensure insulation fills all voids in the cavity uniformly and fits around obstructions such as wiring cleanly.

Fire safety requirements

All insulation applied under this standard must meet the following, except as identified below in bullet "Specific conditions where a thermal barrier is not required."

- Flame spread index of 75 or less (ASTM E84, "Standard Test Method for Surface Burning Characteristics of Building Materials").
- Smoke development index of 450 or less (ASTM E84) or UL 723, "Standard for Test for Surface Burning Characteristics of Building Materials."
- Include a thermal barrier that meets one of the following:
    - Prescriptive Thermal Barriers.—Either of the following materials applied between the insulation and the interior of the building space serves as acceptable thermal barrier:

- 1/2 inch (13 mm) fire-rated gypsum board
- 23/32-inch (18.2 mm) wood structural panel

- Tested Thermal Barrier Materials.—A material that is tested in accordance with and meets the acceptance criteria of both tests of National Fire Protection Association (NFPA) 275, "Standard Method of Fire Tests for the Evaluation of Thermal Barriers." Thermal barrier materials typically tested under NFPA 275 include spray-applied cementitious materials, spray-applied cellulosic materials, Portland cement plaster, and other various proprietary materials. The standard method of fire tests for the evaluation of thermal barriers includes both of the following:
  - Temperature Transmission Fire Test (Part I).—The temperature rise of the unexposed surface of the barrier material is limited within the test standard.
  - Integrity Fire Test (Part II).—To establish that the barrier material will sufficiently remain in place during a fire scenario by complying with one of the following 15-minute fire test standards: UL 1715, FM 4880; or UL 1040 large-scale fire test standards or tested to meet the acceptance criteria in annex C of NFPA 286, "Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth."
- Alternative Thermal Barrier Assemblies.—Many assemblies without thermal barriers have earned various building code acceptances as an alternative to the use of thermal barriers over insulation based on large-scale fire testing. An acceptable assembly, consisting of either the exposed foam plastic, the foam plastic or other insulation with a fire-protective product, meets the following requirements:
  - The assembly must pass either UL 1715, FM 4880, or UL 1040 large-scale fire test standards or be tested to meet the acceptance criteria in annex C of NFPA 286.
  - The insulation material must be installed at a thickness equal to or less than the thickness tested in the previous paragraph.
  - The tested assembly is consistent with planned use for installation in walls, ceilings, or both.

- Specific conditions where a thermal barrier is not required.
  - Masonry or Concrete Installations.—A thermal barrier is not required in a masonry or concrete wall, floor, or roof system where the insulation is covered on each face by not less than 1-inch (25-mm) thickness of masonry or concrete.
  - Sill Plate, Joist Header, and Rim Joist Installations.—A thermal barrier is not required for these installations when all of the following requirements are met:
    - The maximum thickness of the foam plastic is 3¼ inches (82.6 mm).
    - The density of the foam plastic is 1.5 – 2.0 pounds per cubic foot (pcf) (24 to 32 kg/m3).
    - Flame spread index of 25 or less (ASTM E84).
    - Smoke development index of 450 or less (ASTM E84)
  - Attic Insulation.—A thermal barrier is not required when fiberglass loose fill or unfaced batt insulation is installed to retrofit the unoccupied attic area of agricultural structures.

Vapor retarders

Complete a hygrothermal evaluation to determine the need, location, and selection of a vapor retarder. Perform analysis in accordance with the latest edition of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) "Handbook of Fundamentals"; "Midwest Plan Service, Structures and Environment Handbook" (MWPS-1); or other locally accepted procedure approved for use by the NRCS SCE. Use analysis of typical installations for the climatic region and expected moisture production (such as animals, heaters, etc.).

When needed, select a vapor retarder that meets the level identified by the hygrothermal analysis. Install required vapor retarders in accordance with the manufacturer's recommendations.

Insulation for agricultural buildings except for greenhouses

Meet the minimum R-values of the wall and attic components provided in table 1 or provide a building energy analysis that demonstrates that the whole building assembly will meet or exceed the energy efficiency of the R-values. Meet the R-values provided in ASHRAE 90.1-2016, "Energy Standard for Buildings Except Low-Rise Residential Buildings," tables 5.5-1 through 5.5-8, for additional types of building envelope components not shown in table 1 below.

Table 1 -Minimum Insulation R-values for Opaque Building Envelope Components (1)

	Minimum R-values (Btu/(h ft2 °F)) (2)(3)					
	Partially Conditioned Space			Fully Conditioned Space		
Climate zone (4)	Attic	Wood framed walls, above grade	Walls, below grade	Attic	Wood framed walls, above grade	Walls, below grade
1	R-13	NR(5)	NR	R-38	R-13	NR
2	R-19	R-13	NR	R-38	R-13	NR
3	R-19	R-13	NR	R-38	R-13	NR
4	R-30	R-13	NR	R-49	R-13+3.8 c.i.(6) or R-20	R-7.5 c.i.
5	R-30	R-13	NR	R-49	R-13+7.5 c.i or R-19+5 c.i.	R-7.5 c.i.
6	R-30	R-13	R-7.5	R-49	R-13+7.5 c.i or R-19+5 c.i.	R-10 c.i.
7	R-38	R-13+3.8 c.i.	R-7.5 c.i.	R-60	R-13+7.5 c.i or R-19+5 c.i.	R-15 c.i.
8	R-38	R-13+7.5 c.i.	R-7.5 c.i.	R-60	R-13+18.8 c.i.	R-15 c.i.

(1) Data Source: Reference ANSI/ASHRAE/IES Standard 90.1-2016, "Energy Standard for Buildings Except Low-Rise Residential Buildings," Tables 5.5-1 through 5.5-8. The R-values provided in this table for Partially Conditioned Space and Fully Conditioned Space correspond with the semiheated and nonresidential R-values, respectively, in the referenced ASHRAE 90.1-2016 tables. Refer to ASHRAE 90.1-2016 for additional building component types such as other roof types, wall types, floors, slab-on-grade.

(2) The values shown do not represent the values necessary to provide a heat balance between heat produced by products or animals and the heat transferred through the building. The minimum R-values may be reduced if the latent heat analysis demonstrates a needfor less insulation to maintain the target climate in the building under allweather conditions.

(3) For poultry grow-out buildings, Climate Zones 1 through 4 use minimum R-values (Btu/(h ft2 °F)) of R-19 in the roof/ceiling and R-7 in the walls.

(4) Refer to figure 1. AHSRAE 90.1-2016, Annex 1, Table Annex 1-1 provides a listing of U.S. Climate Zones by State and County.

(5) NR = No insulation requirement.

(6) c.i. = continuous insulation. Insulation that is uncompressed and continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope. (ASHRAE 90.1-2016). Continuous insulation has an R value associated with it. For example, R-13 + 7.5 c.i. is wall cavity insulation of R-13 plus a continuous insulation wrap of R-7.5.

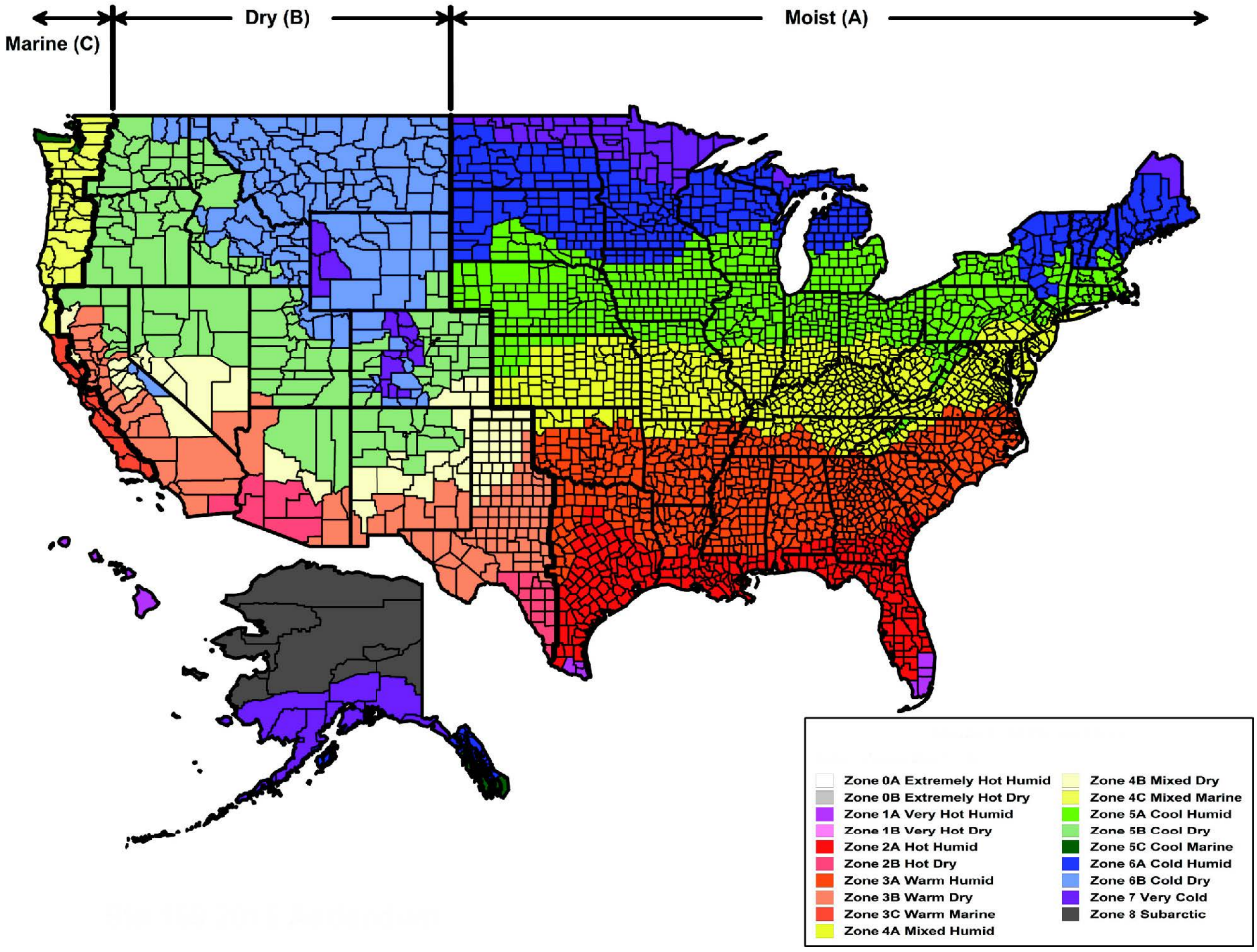

Figure 1: Climate zones for United States counties.

Insulation for greenhouses
Insulate greenhouse perimeter knee walls where light quality won't be adversely affected, and other areas of the greenhouse perimeter.

Install insulation with a minimum insulation value of R-5 above the interior floor elevation to a height that is compatible with the operation such as up to bench height.

Use rigid insulation for greenhouse endwalls and sidewalls.

Where rigid insulation is not practical, use insulated material faced with foil on both sides with a minimum insulation value of R-1.5 on curved greenhouse sidewalls or other areas where flexibility is required. Install a minimum nominal thickness of 3/16" toa minimum height of 3 feet above the interior floor elevation.

Alternative greenhouse insulating methods and materials may be used as approved by the NRCS SCE.

Additional Criteria for Commercial Doors and Windows

The insulation values of the buidling envelope will meet or exceed the R-values in table 1 above.

Select door and window materials based on temperature extremes, moisture conditions in the building, and expected UV light exposure.

Use windows and doors labeled to meet U.S. Environmental Protection Agency (EPA) Energy Star minimum rating associated with the facility's climate zone shown in figure 2, or ASHRAE 90.1-2016, Tables 5.5-1 through 5.5-8 and Section 5.8.2, "Fenestration and Doors," or provide an energy analysis that demonstrates that the door and window assembly will meet or exceed the energy efficiency of the R-values, as applicable.

Install doors and windows in an airtight manner in accordance with manufacturer's recommendations.

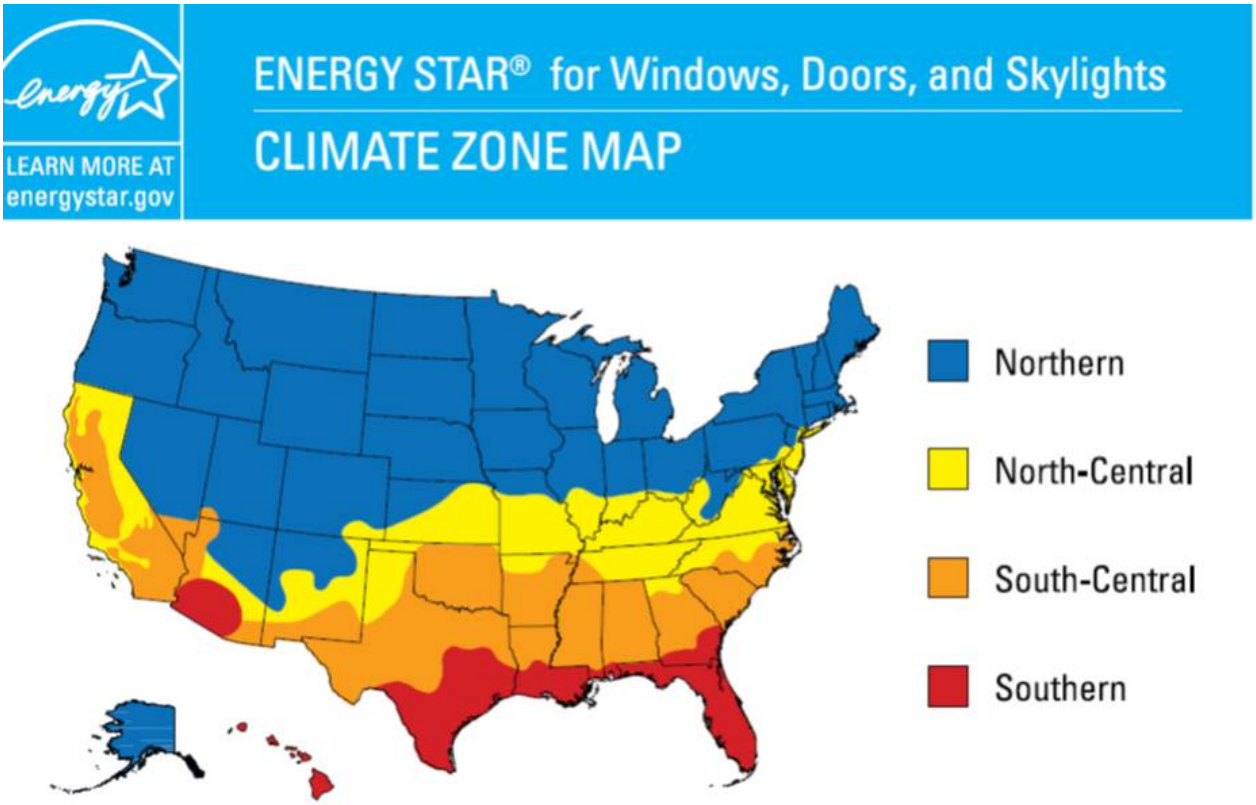

Figure 2 – Energy Star Climate Zone Map

Additional Criteria for Energy Screens

Select screens with a warranty life of 5 years or greater on strength and flexibility.

Use screen materials that are flame retardant. Use firebreaks where needed to limit screen-to-screen fire spread. Materials and installation must meet all local fire codes.

Use stainless steel support wire (not cable).

When screens are in the closed position, screens must fit tightly where the screen meets the sidewalls, framing, or gutters.

Greenhouse screens

Select greenhouse screens based on intended use such as heat retention, day time shading. or both.

Select screens according to the energy savings as determined by the transmissivity, emissivity, and reflectivity of heat radiation; the air permeability of the material; and the humidity transport through the material.

Select screens with a minimum energy savings potential of 40 percent according to the manufacturer.

Install screens either gutter-to-gutter (screen pulled flat across the structure at gutter height) or truss-to-truss (screen pulled between adjacent trusses).

Livestock housing curtains
Select screens that have a minimum R-value of 4.

CONSIDERATIONS

Consider the need to move or modify electrical wiring, water pipes, fuel supply pipes, light fixtures, or other infrastructure for installation of the practice.

Consider using windows to control solar heat gain meeting climate zone-specific Energy Star rated or ASHRAE 90.1-2016, Tables 5.5-1 through 5.5-8, and Section 5.5.4.4, “Fenestration Solar Heat Gain Coefficient (SHGC).”

Consider insulating and sealing the ventilation fan or other openings when not in use for an extended period.

Consider replacing roofs with a cool roof meeting ASHRAE Standard 90.1-2016, Section 5.5.3.1.1 in climate zones 1 through 3.

Consider other design features within the agricultural building where relative humidity is maintained above 85 percent. Refer to the latest edition of ANSI/ASAE EP475, “Design and Management of Storages for Bulk, Fall-Crop, Irish Potatoes,” or other appropriate guidelines.

Consider long-term cost savings and associated life cycle costs to increase long-term profitabiity.

Additional Considerations for Greenhouses
Consider installing multiple screens in greenhouses to increase heat retention and shading to achieve energy savings.

Consider improving the efficiency of moveable greenhouse screens with automatic temperature or moisture sensors, or both, and controls.

Consider installing greenhouse insulation in a manner that is conducive to removal during the warmer months of the year in greenhouses that use sidewalls for ventilation.

Consider taping rigid insulation edges to extend the durability of the materials when used on a seasonal basis.

Consider installing energy efficient glazing materials.

When expanding an existing greenhouse, consider gutter connected additions which minimize the external surface area and heat loss.

Consider installing a heat sink to absorb and retain heat.

Consider energy savings as determined by the transmissivity, emissivity, and reflectivity of heat radiation, the air permeability of the material, humidity transport through the material, ability to fold compactly, durability, and functionality when selecting screen materials.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for building envelope improvements that describe the requirements for applying the practice to achieve the intended purpose. As a minimum, include—

- Plan view and cross-section drawings and description of the existing and modified or retrofitted building envelope and related components or devices, if applicable.
- Description and characteristics of materials to be applied or installed in the building envelope.
- Installation details associated with the practice.
- Estimated quantities.
- Requirements for disposal of replaced materials, if applicable.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. Requirements may include but are not limited to—

- Annual inspection and testing of building envelope components, including as appropriate, but not limited to—
  - Building envelope.—Check for leaks (e.g., visual inspection, fogger, or pressure test).
  - Insulation.—Depth in ceiling, gaps, shrinkage, adhesion, tears.
  - Vapor barriers.—Tears or other holes.
  - Energy screen.—Visual inspection along screen edges where it meets sidewalls, framing, or gutters; look for gaps, tears, holes, or other damage while the screen is fully extended.
  - Control systems.
- Records of annual inspections and finding.
- Vector control program to minimize damage to building envelope.
- Any items identified during the annual inspection should be repaired or replaced within 30 days of finding. Repair as needed to maintain energy efficiency.
- Energy screen replacement within the life span of the practice.

REFERENCES

American Society of Heating, Refrigeration and Air Conditioning Engineers. 2017. ASHRAE Handbook – Fundamentals. Atlanta, GA.

American Society of Heating, Refrigeration and Air Conditioning Engineers. 2016. ANSI/ASHREA/IES Standard 90.1-2016 Energy Standard for Buildings Except Low-Rise Residentail Buildings. Atlanta, GA.

American Society of Agricultural and Biological Engineers. 2018. Design and Management of Storages for Bulk, Fall-Crop, Irish Potatoes. ANSI/ASAE EP475.3 JAN2018. St. Joseph, MI.

American Society of Agricultural and Biological Engineers. 2017. Guidelines for the Use of Thermal Insulation in Agricultural Buildings. ANSI/ASAE S401.2 (R2017). St. Joseph, MI.

American Society for Testing and Materials. 2019. Standard Practice for Installation of Exterior Windows, Doors and Skylights. ASTM E2112-19. Subcommittee: E06.51. West Conshohocken, PA.

American Society for Testing and Materials. 2018. Standard Specification for Elastomeric Joint Sealants. ASTM C920-18. Subcommittee: C24.10. West Conshohocken, PA.

International Code Council, Inc. 2018. International Building Code. 2018 IBC. Country Club Hills, IL.

International Code Council, Inc. 2018. International Energy Conservation Code. IECC-18. Country Club Hills, IL.

Midwest Plan Service. 1987. Structures and Environment Handbook, MWPS-1. Ames, IA.

Bartok. J.W. 2001. Energy Conservation for Commercial Greenhouses. Natural Resource, Agriculture, and Engineering Service (NRAES). (NRAES-3). Ithaca, NY.

National Fire Protection Association. 2019. Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth. NFPA 286. Quincy, MA.

Spray Polyurethane Foam Alliance. 2016. Thermal and Ignition Barriers for the Spray Polyurethane Foam Industry. SPFA 126. https://sprayfoam.org.

Spray Polyurethane Foam Alliance. 2016. Guideline for Insulating Metal Buildings with Spray-Applied Polyurethane Foam. SPFA-134.https://sprayfoam.org.

Spray Polyurethane Foam Alliance, 2015. Moisture Vapor Transmission. SPFA-118. https://sprayfoam.org.

U.S. Environmental Protection Agency and U.S. Department of Agriculture. ENERGY STAR. http://www.energystar.gov/.